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tations of structure and habit. The second is by the production of new individuals to take the place of those that have been overcome. Now, as different animals exhibit varying degrees of ability to adjust themselves to their environment, so also their reproductive power may be small or great. In estimating this reproductive power four factors, as Herbert Spencer points out,<sup>1</sup> are to be taken account of, namely, (1) the age at which reproduction commences, (2) the frequency with which broods are produced, (3) the number contained in each brood, and (4) the length of time during which the bringing forth of broods continues.

Accordingly, for the special case of *Physa heterostropha* we have the following results:—

1. Age at which reproduction begins, 5 months.
2. Frequency of broods, 1 in about  $2\frac{7}{10}$  days.
3. Number in each brood, 30 average.
4. Reproductive period, 4 months, March to July.

Some addition ought to be made to this actually observed period, inasmuch as the snails had certainly already entered upon it at the time of their capture, and, further, instead of closing normally, it seems to have been violently interrupted. Just how much the period of reproduction is to be extended I have no means of determining, unless the fact that the young snails of the first brood were observed reproducing themselves in September warrants an extension of at least two months, making it six months instead of four.

Assuming, then, that the reproductive season extends from March to September, and assuming, further, somewhat arbitrarily, that the snail lives but two years, we have, on the basis of facts above mentioned, the following estimate of the total number of the offspring of a single pair:—

At close of first season.....	1,900
950 pairs at close of second season.....	1,805,000
Original pair at close of second season.....	1,900
Total number of offspring in two years.....	1,808,800

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### NEBRASKA SUGAR SCHOOL.

PROFESSOR LLOYD has just made the first formal report of the sugar school at the State university, Lincoln, Neb., of which the following is a summary: The school opened on Jan. 5 with an enrollment of twenty-five students. These students were mostly members of other classes in the chemical department of the university; the only preparation required for entrance being a clear conception of the principles of elementary chemistry, such as may be obtained in some of the high schools of Nebraska.

The course consisted of two lectures a week, with five hours of laboratory work. The lectures as given by Mr. Lyon embraced the following subjects: 1. Chemistry of the sugars; 2. technology of beet-sugar manufacture; 3. culture of the sugar beet.

The lectures under the first head were designed to give the students an idea of the position of sugars as a class in the series of compounds of carbon, and their relation to others of these compounds, together with a knowledge of the properties and characteristics of each of the sugars.

The cause and effects of fermentation upon sugar solutions were carefully studied. Other important principles relating to the manufacture of sugar, as the compounds of the sugars with lime, melassigenic action, etc., were taken up in order to prepare the student for the complete understanding of the practical application of these principles in sugar factories.

A discussion of the methods of the analysis used in the laboratory was given from time to time throughout the course.

Under the second head of lectures, the various processes that the beets, juice, and sugars undergo from the washers to the granulator were studied in detail. Both the French and German forms of machinery were described. As each process was studied, the methods of the analysis of its products and by-products was referred to. The study of sugar-house control was in this way presented to the student.

During the latter part of the winter term, Professor DeWitt B. Brace gave the class four valuable lectures on the theory of light. His lectures included the following subjects: 1. The wave theory of light; 2. polarization of light; 3. rotation of the plane of polarization; 4. application of these principles to the polariscope and to the different forms of saccharimeters.

The lectures were finely illustrated by means of the apparatus in possession of the physical laboratory. This course in the physics of light was followed by lectures in the chemical department on the use of the saccharimeter, methods of setting prisms to obtain a clear field, adjustment of the compensating wedges, methods for testing the accuracy of instruments.

The laboratory work of the course consisted in analyses of the various products and by-products of the sugar factory. The samples used were obtained from the Norfolk sugar factory during the last campaign. One of the students did some advance work in the absorption of sucrose by bone black and the volume of the lead precipitates.

The spring term was devoted to a course of lectures on the culture of the beet. This course embraced the following topics:

1. Origin and history of the beet.
2. External characteristics of a good sugar beet, its roots and foliage.
3. Composition and structure of the root.
4. Relation of the leaves to the root.
5. Food of the plant.
6. Relation of the plant to the atmosphere and to the soil.
7. Conditions governing the growth of the plant, and changes during vegetation.
8. Fertilizers, preparation of the soil, planting, cultivating, thinning, etc.
9. Production and improvement of the seed.

These lectures were supplemented by practical work at the station farm, which may be continued throughout the summer at the option of the student. The course closed May 6.

Encouraged by this prosperous beginning of the first beet-sugar school in the United States, it is hoped that in the coming year the work may be greatly extended. Several students who have taken the course outlined are thoroughly prepared to do polariscopic work in sugar factories.

### SECONDARY BATTERIES.<sup>2</sup>

WHEN a lead-peroxide cell is discharged, sulphate of lead is the ultimate product on both plates, and when it is charged again this lead sulphate is oxidated on one plate and reduced on the other. This fact was published in 1882 by Dr. J. H. Gladstone and the late Mr. Tribe in *Nature*. Taken by itself, however, it does not explain how it is that during charge the potential difference of a cell will rise rapidly from 2.1 volts to 2.13 volts, then slowly to 2.2 volts, and

<sup>1</sup> Biology, Vol. II., p. 395.

<sup>2</sup> From Engineering of May 20.

afterwards rapidly to 2.4 volts, or even higher. Upon disconnection of the charging current the potential difference drops suddenly to about 2.1 volts, and then on discharge falls rapidly to 1.95 volts. The main part of the discharge takes place between 1.95 and 1.9 volts, and if it be continued beyond the latter point the potential difference rapidly falls to 1.6 volts, the gradient below 1.8 volts being very steep. Last week, and again yesterday, Dr. Gladstone showed the Institution of Electrical Engineers that the variations in the strength of the sulphuric acid are the main causes of the variations in the electro-motive force. Starting with a properly formed cell which has been discharged, there are two leaden supports; on one of these is a mixture of lead sulphate ( $\text{PbSO}_4$ ) with more or less lead peroxide ( $\text{PbO}_2$ ); on the other is also a mixture of lead sulphate with more or less of spongy metallic lead. Each of these mixtures is a porous layer. The act of charging converts the lead sulphate on one plate into  $\text{PbO}_2$ , and on the other into spongy lead. In the operation there is an abundant formation of sulphuric acid in the pores of each plate, while an equivalent amount of water disappears. In addition to this chemical effect sulphuric acid is, by electrolytic action, heaped up against the positive (peroxide) plate, and withdrawn from the neighborhood of the negative (spongy lead) plate. The increase of acid strength around the positive plate was proved experimentally by the author, while it is matter of common knowledge that the density of all the liquid in a cell rises during charge.

When a cell is fully charged and left to stand, the strength of the acid commences to equalize itself through the liquid. This is brought about by three causes — diffusion, local action, and reduction by  $\text{H}_2\text{O}_2$ . These actions occur at the positive plate, where the acid in the pores works out, at first rapidly and then more slowly. At the same time energetic local action is set up between the  $\text{PbO}_2$  and its supporting lead frame, with the formation of sulphate of lead, and the consequent absorption of sulphuric acid from the liquid. The temporary evolution of oxygen gas from a well-charged plate has been attributed to the reaction of hydrogen dioxide on peroxide of lead. At the negative plate equalization of acid strength takes place by diffusion, and also by a direct, slow, chemical action of the sulphuric acid on the lead, producing lead sulphate and hydrogen gas. This latter gas, being formed in the pores of the spongy lead, chokes them and hinders the diffusion of the acid, rendering it very slow.

During the discharge of a cell all the causes just enumerated as tending to produce equalization of acid strength, continue in operation, and to them is superadded the ordinary discharge reaction of the cell. At the positive plate the lead peroxide, with sulphuric acid existing in its pores ( $\text{PbO}_2 + \text{H}_2\text{SO}_4$ ), becomes sulphate of lead and water ( $\text{PbSO}_4 + \text{H}_2\text{O}$ ). At the negative plate spongy lead with sulphuric acid in its pores ( $\text{Pb} + \text{H}_2\text{SO}_4$ ) also becomes sulphate of lead and water ( $\text{PbSO}_4 + \text{H}_2\text{O}$ ). Further, by electrolytic action sulphuric acid is transferred from the  $\text{PbO}_2$  to the Pb plate. The excess of acid originally about the  $\text{PbO}_2$  plate rapidly disappears by these various agencies, and the acid on both plates is reduced pretty nearly to the same strength as that of the intermediate liquid. After this there is a gradual withdrawal of acid from the liquid in the pores, more or less compensated by diffusion inwards from the intermediate liquid. This brings about the reduction in the strength of the whole acid, which is well known to take place during discharge. The strength of the acid in the pores will be determined by the relative values of the rate of withdrawal

and the rate of diffusion. But while the rate of withdrawal continues constant for a given current discharge, the rate of diffusion rapidly diminishes. The rate of weakening of the acid is, therefore, a constantly increasing one, and may finally become so rapid that the acid strength of the liquid against the working surfaces of the plates is very low, or almost *nil*.

It being shown that the strength of the acid against the plates of a secondary battery is constantly varying during charge, repose, and discharge, the authors of the paper, from which we have quoted, set themselves to prove experimentally that a change of electro-motive force is produced by a change in the strength of the acid. Taking a pair of fully formed and carefully washed plates they were placed in a series of solutions of gradually increasing strength of acid, and left in each for fifteen minutes. The acid strengths and electro-motive force are given in the following table: —

Percentage of Acid.	Electro-motive Force (Volts).
6.5	1.887
9.5	1.898
11.5	1.915
16.2	1.943
21.7	1.978
29.2	2.048
33.7	2.088
43.0	2.170

In a second set of experiments the Pb plate was kept in acid of 14.0 per cent strength, while the acid around the positive plate was varied from 6.5 to 81 per cent. The result confirmed those of the first set of experiments, but it was shown that the electro-motive force depends on the strength of the acid at both electrodes. Several other series of experiments were made in different ways, but all confirming the opinion that change in acid density was accompanied by a change of electro-motive force.

We have not space to follow Messrs. Gladstone and Hibbert through the vast amount of confirmatory evidence they adduced from their own experiments, and from the records of the researches of others, in support of their hypothesis. We may, however, notice one point. Applying Lord Kelvin's law as to the relation between the electro-motive force of a cell, and the thermal value of the chemical actions contributing to it, they find that the voltage of a  $\text{PbO}_2 - \text{Pb}$  cell, in which there was nothing but pure  $\text{H}_2\text{SO}_4$ , would be 2.627; by experiment they made it 2.607 volts. With pure water in the cell the result is, by calculation, 1.35 volts; by experiment, 1.36 volts. In charging an accumulator the current has, as already shown, to do extra work in concentrating  $\text{H}_2\text{SO}_4$  at the  $\text{PbO}_2$  plate, and the energy equivalent to that work must be obtained from an increased potential difference. This explains how it is that potential difference is so much greater during charge than during discharge. For a dyad gramme equivalent of  $\text{H}_2\text{SO}_4$ , concentrated from a 10 per cent solution to 100 per cent, about 17,000 calories will be needed, equal to .37 of a volt. The calculated charging electro-motive force must, therefore, be at least 2.3 volts.

The lesson to be learned from the paper is the desirability of promoting diffusion in the liquid of the cell, so as to keep the whole of the same density. At present the heavy acid slides down the  $\text{PbO}_2$  plate and accumulates at the bottom. This leads to differences of current density in different parts of the plate, and will also give rise to potential differences

on each of the plates, and thus produce local action and the formation of lead sulphate. It would not be a difficult matter to effect such diffusion, and the experiment would be one of considerable interest.

#### NOTES AND NEWS.

THE annual meeting of the Society of German Men of Science and Physicians, according to *Nature*, will be held at Nürnberg from September 12 to 18. At the same time and place there will be a meeting of the German Mathematical Association. In connection with these meetings there will be a mathematical exhibition, including models, drawings, apparatus, and instruments used in teaching and in research in pure and applied mathematics. The project has the support of the Bavarian Government, and those who are organizing the exhibition have secured the co-operation of various competent men of science, and of the mathematical departments of some colleges, besides that of prominent publishers and well-known technical institutions. Space will be granted free of charge to exhibitors.

— Mr. E. H. Parker, the British consul at Kiangchow, in Hainan, a large island off the southern coast of China, mentions a curious phenomenon in connection with the tides of that port. The tides inside the inner harbor, as we learn from *Nature*, require several years of careful observation before they can be tabulated. It appears certain, however, that there are always two tidal waves a day, though one is so much more considerable than the other that the effect is often practically that of one single tide in the twenty-four hours. The easterly and westerly currents through the straits are not necessarily connected with the rise and fall of the water, either there or in port. The phenomenon of "slack water" (*morte eau*) is also observable every ten days or so at Haiphong, and is probably owing to much the same causes as at Hoihow. At Tourane in Tonquin, too, it is popularly thought that there is usually but one tide within the twenty-four hours. This tide is felt away up to the citadel of Quangnam. In the Gulf of Tonquin the incoming tidal wave flows from the south, a fact which perhaps accounts for the singular circumstance that the westerly current in the Hainan Straits always sets for sixteen hours. One at least of the tidal waves from the east, which pass Hoihow, cannot get through the straits to Tonquin so soon as that portion of the same wave which takes a circuitous course by way of Annam.

— A Report of the State Geologist of Missouri, dated June 3, shows that much attention has been given to the study of the zinc and lead deposits, and in this connection examinations have been made in Jasper, Newton, Lawrence, Greene, and St. Francois Counties. In addition, detailed mapping has been prosecuted in Jasper County, and about 140 square miles have been covered during the past month. Further, there has been collected in Jasper County a large number of charts showing the location of mining properties, shafts, and ore bodies; and a great amount of statistical matter relating to these. The material thus acquired will be used in the preparation of the general report upon the zinc and lead deposits and also in the special report which will accompany the maps of Jasper County, now in preparation. In connection with the examination of the iron-ores, stratigraphic studies of the Ozark region have been prosecuted along the Big Piny and Gasconade Rivers in Texas, Pulaski, Phelps, Maries, Osage, and Gasconade Counties. In addition, iron-ore deposits have been inspected in Ripley, Carter, Wayne, and Butler Counties. The clays of the State have been subjects of further examination in both the field and the laboratory, deposits having been visited in St. Louis, Jefferson, Washington, Madison, Bollinger, Carroll, Chariton, and Randolph Counties. The study of the Quaternary geology of the State has been prosecuted in Jackson, Lafayette, Johnson, Macon, Randolph, and Saline Counties. In Greene and Polk Counties a small amount of systematic geological mapping has been done. The excessive rains during the past month have not only made all the field-work difficult and disagreeable, but have made certain work impossible, and have materially retarded the progress in other directions. It is greatly to

the credit of the assistants of the survey that, notwithstanding the hardships endured and the difficulties overcome, such advance has been made. In the office the preparation of reports has been constantly in progress. This includes the original composition, the revision, and preparation for the printer, the correction of proof, the drawing of maps and illustrations. The reports which have thus specially received attention during the past month are: the report on the iron ores; the report on the mineral waters; the report on paleontology; the report on the Higginsville sheet; the reports on the Warrensburg, Iron Mountain, and Mine La Motte sheets; and the report on the crystalline rocks.

— At a meeting of the American Philosophical Society, Philadelphia, May 20, the following preambles and resolutions were read and considered: "Whereas, This Society did in the year 1843 celebrate the Centennial Anniversary of its foundation by a series of addresses, meetings, receptions, exercises, etc., upon the 25th, 26th, 27th, 28th, 29th, and 30th days of May, the results of which were published in a special volume of over two hundred pages; and, Whereas, We are approaching the Sesqui-Centennial Anniversary of the same auspicious event; therefore, be it Resolved, That the Society will celebrate the same in a worthy and becoming manner. Resolved, That the president be authorized to appoint a committee of five members to make all necessary arrangements for the same and with full power to act, and that the president be *ex-officio* a member of said committee." The preambles and resolutions, being considered by the society, were unanimously agreed to. The president subsequently appointed as said committee Messrs. Henry Phillips, Jun., chairman, J. Sergeant Price, Daniel G. Brinton, Richard Vaux, and William V. Keating.

— The usual monthly meeting of the Royal Meteorological Society was held on Wednesday evening, May 18. The following papers were read: (1) "Raindrops," by Mr. E. J. Lowe, F.R.S. The author has made over three hundred sketches of raindrops, and has gathered some interesting facts respecting their variation in size, form, and distribution. Sheets of slate in book-form, which could be instantly closed, were employed; these were ruled in inch squares, and after exposure the drops were copied on sheets of paper ruled like the slates. Some drops produce a wet circular spot; whilst others, falling with greater force, have splashes around the drops. The same-sized drop varies considerably in the amount of water it contains. The size of the drop ranges from an almost invisible point to that of at least two inches in diameter. Occasionally large drops fall that must be more or less hollow, as they fail to wet the whole surface inclosed within the drop. Besides the ordinary rain drops, the author exhibited diagrams, showing the drops produced by a mist floating along the ground, and also the manner in which snowflakes, on melting, wet the slates. (2) "Results of a Comparison of Richard's Anémo-Cinémographe with the Standard Beckley Anemograph at the Kew Observatory," by Mr. G. M. Whipple. This instrument is a windmill vane anemometer, and is formed by six small wings or vanes of aluminium, four inches in diameter, inclined at 45°, rivetted on very light steel arms, the diameter of which is so calculated that the vane should make exactly one turn for a meter of wind. Its running is always verified by means of a whirling frame fitted up in an experimental room where the air is absolutely calm, and, if necessary, a table of corrections is supplied. The recording part of the apparatus differs entirely from any other anemometer, and is called the Anémo-Cinémographe, and in principle is as follows: The pen, recording on a movable paper, is wound up at a constant rate by means of a conical pendulum acting as a train of wheel-links, whilst a second train, driven by the fan, is always tending to force it down to the lower edge of the paper; its position, therefore, is governed by the relative difference in the velocity of the two trains of wheel-work, being at zero when the air is calm, but at other times it records the rate of the fan in meters per second. The author has made a comparison of this instrument with the Standard Anemometer at the Kew Observatory, and finds that it gives exceedingly good results. (3) "Levels of the River Vaal at Kimberley, South Africa, with Remarks on the Rainfall of the Watershed," by Mr. W. B. Tripp. Measurements of the height of the River Vaal have for several